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Simple Transistor Switch Detects Thermocouple Fault Conditions

THERMOCOUPLES AND THEIR leads often have to detect open-circuit or short-circuit faults. However, it is very difficult to distinguish a valid millivolt temperature signal from an open/short-circuited thermocouple, which generates a very similar signature at the input. The conventional solutions employ concepts based on tone generation/reflection or current-source circuits. This may prove to be costly, particularly in low-cost applications like automotive designs.

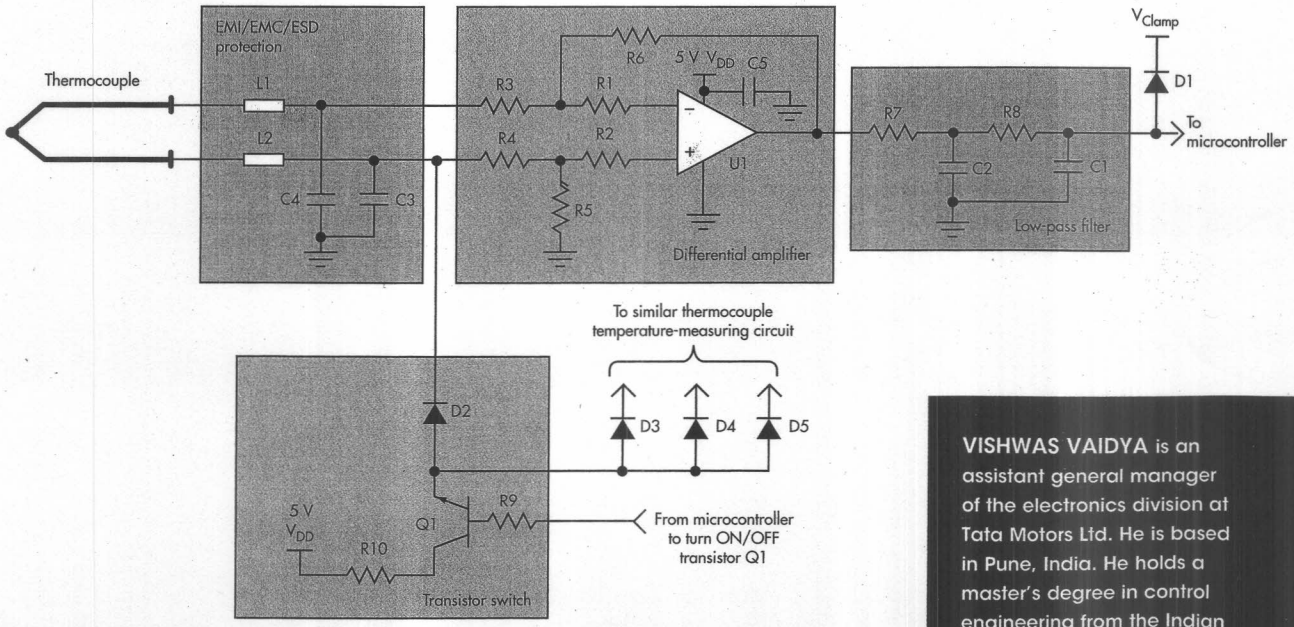
The circuit in the figure shows a low-cost solution based on a transistor switch (Q1). The transistor is off under normal conditions, when the differential amplifier built around U1 amplifies the thermocouple signal. The microcontroller periodically tests for a possible open-circuit condition by momentarily switching Q1 on and monitoring the amplifier output. When Q1 is switched on during normal condition, it injects a fixed dc signal onto the thermocouple signal (determined by R10, R4, and R5). This pumps a dc current through the thermocouple resistance, injecting an additional differential signal input across the thermocouple.

In turn, this causes a moderate increase at amplifier U1's output (compared to when Q1 is off). If Q1 is switched on, then under short-circuit conditions at the thermocouple input terminals of the amplifier, U1 does not change at all (compared to the Q1 off condition).

Under open-circuit conditions at the thermocouple, U1 automatically gets configured into a unity gain buffer. Hence, an increase of a few volts appears at the output of the U1, which is now a unity gain buffer (determined by R4, R5, and R1). The microcontroller recognizes this increase of a few volts (compared to the Q1 off condition) to correctly detect the open-circuit condition.

Diodes D1, D2, and so on allow this technique to be shared across multiple thermocouple amplifiers in a single application. Resistors R1 and R2 protect U1's inputs against an accidental short circuit of thermocouple wires to the positive supply line, which is possible in automotive applications, and can be omitted if not required in your application.

In summary, switching transistor Q1 on results in a moderate increase, no change, or a large increase at U1's output, depending on whether the thermocouple is in no-fault, short-circuit, or open-circuit conditions, respectively, enabling the microcontroller to detect the condition.



By briefly switching a dc current into a thermocouple loop and observing the result at an input amplifier, the system microcontroller can assess if the loop is good or in a short-circuit or open-circuit fault mode.

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